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ECL 231

DOES YOUR HAMMER CHIP? (A)

Injury from a flying chip from a 20-pound sledge hammer! Why? -- The story of the investigation into the source of the chip.

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PART A

CIRCUMSTANCES OF ACCIDENT

Mr. D. was employed in a shop where 20 lb. sledge hammers were sometimes used to remove dies from a forging machine. During one such situation, Mr. D. was struck in the throat by a chip from a fellow worker's sledge hammer. The metal chip lodged in Mr. D's lung. A personal injury suit involving product liability ensued with Mr. D. suing the hammer manufacturer and the steel supplier.

OBSERVATIONS

The 20 lb. sledge hammer in question was the type given in Federal Specifications GGG-H-86c, Hammer, Hand. (See Exhibit A1). Visual study indicated that there were a number of craters on the edge of the striking faces where chips had previously been ejected. The original chamfer of the striking faces was nearly gone and the length of one side of the hammer was approximately 0.2" shorter than the other side indicating more use of that side. A comparison of a new hammer with the old hammer indicated that the overall length of the used hammer was about 0.25" shorter than a new hammer.

Three additional 20 lb. sledge hammers were obtained from the plant where the accident occurred. Number 1 hammer was new. Number 2 hammer was used but had not been redressed. Number 3 hammer was used, redressed an unknown number of times, with numerous missing chips on the periphery of its faces. These three hammers were compared with hammer number 4 which caused the injury. Exhibit A2 shows the hammers and various sections used for analyses. It can be seen that, as the hammer is used and redressed repeatedly, the striking surfaces show excessive deformation and wear.

Chemical analysis indicated the hammer was SAE 1060 steel. Analysis of the chip in question also gave the same chemistry. It fit one of the craters on the periphery of the face of the hammer in question. There was no question that the chip came from this hammer (No. 4).

MICROSTRUCTURAL ANALYSIS

Samples of material from hammer number 4 and the chip were mounted in bakelite, polished, and etched. Optical and scanning electron microscope studies showed evidence of a white layer or line on the curved side which matched the crater on the hammer. (See Exhibit A3) Other samples from the periphery of the hammer face were prepared in cross sections. Those samples which contained old craters (missing chips) showed a white layer on the surface of the crater while other areas of the edge of the hammer face showed a conical or moon-shaped layer. (See Exhibit A4) Higher magnification of the white layers revealed cracks as shown in Exhibit A5. Exhibit A6 shows a portion of a white layer split from the main edge.

HARDNESS TESTS

The mounted samples were subjected to hardness tests. The core material gave Rockwell C values of 42-46 while the white areas gave values of about 65. Exhibit A7 shows a difference in hardness indentation indicating a differential in hardness between core and white layer.

QUESTIONS

1. Is there a defect in the sledge hammer?

2. If there is a defect, how did this come about and where does the responsibility lie?

3. If there is a defect, how could this be avoided?

4. Do you think the plaintiff, Mr. D., has a case and thus should recover damages? Or do you think the defendants are blameless in this instance?

Excerpts from GGG-H-86c

FEDERAL SPECIFICATION

Hammer, Hand, (Forged Steel Head)

3.19 Type X, blacksmiths' or engineers'. Type X hammers shall have a hickory handle conforming to 3.2.2.1. The central cross section of the head shall be square. Heads under 4 pounds shall have medium-ground faces (see 3.4.2). Heads 4 pounds and over shall have medium-coarse-ground faces (see 3.4.3). The remainder of the head shall have a natural finish (see 3.4.5). The faces and peens shall be hardened to not less than 44 nor more than 55 on the Rockwell "C" scale (see 4.4.1).

3.2.2.1 *Hickory handles.* Hickory handles, except types VII and VIII, shall conform to NN-H-93 for the type and size specified except that the handles may be flame treated or color stained and shall be coated with a transparent lacquer that does not conceal the annual rings of growth and the grain of the wood. Handles for types VII and VIII shall be grade B or better as specified in Simplified Practice Recommendation R77-45.

Table XX - Type X, class 1, blacksmiths or engineers, double face.

Weight (see 3.1.1)	Length of head	Distance across flats at face 43/3 -1/16	Handle length, overall 41 -2	Eye		
				Number	Dimensions, minimum	
					P	C
Pounds	Inches	Inches	Inches		Inches	Inches
3 -1/2 to 3 +4	4-1/2 to 4-3/4 ±3/4	1-1/2	15	2 or 3	5/8	7/8
3	4-3/4	1-5/8	15	2 or 3	3/4	1
4	5-1/4	1-3/4	15	2	3/4	1
4	5-1/4	1-3/4	32	2	3/4	1
6	6	2-1/8	32	2	1	1-1/4
8	6-1/2	2-1/4	32	2	1	1-1/4
10 ±8	7 ±1	2-1/2	32	2	1	1-3/8
12	7-1/2	2-1/2	34	2	1	1-3/8
16	8-1/4	2-7/8	34	2	1	1-3/8
20	8-3/4	3	36	2	1-1/4	1-1/2

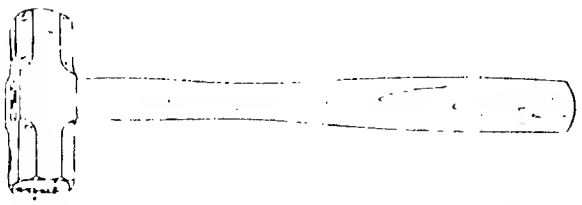


FIGURE 22.—Type X, class 1, blacksmiths' or engineers', double face.

Exhibit A 1

3.3.1.4 *Eye numbers.* The eye number specified for individual types shall be in substantial agreement with the respective eye number shown on figure 1. (Eye numbers do not apply to some tools with steel or fiberglass handles.) Dimensions of eyes are measured from the back side of the hammer head.

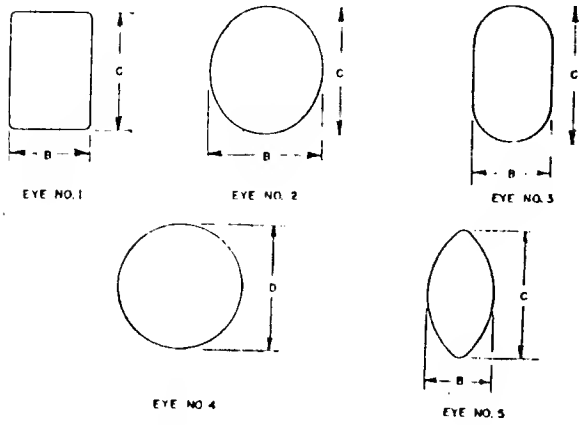


FIGURE 1.—Eye numbers.

3.4.2 *Medium-ground finish, 60-grit.* A medium-ground finish shall be a smooth-ground finish, free from deep scratches and excessive roughness. The surface appearance of the finish shall not be coarser than that resulting from the use of a 60-grit abrasive wheel. Except where a specific finish is specified under individual hammers, the faces or finished parts on all hammers, mauls, and sledges under 4 pounds shall have a medium-ground finish.

3.4.3 *Medium-coarse-ground finish, 46-grit.* A medium-coarse-ground finish shall be a ground finish not coarser than that resulting from the use of a 46-grit abrasive wheel. Except where a specific finish is specified under individual hammers, the faces or finished parts on all hammers, mauls, and sledges 4 pounds and over shall have a medium-course-ground finish.

3.4.4 *Coarse-ground finish, 30-grit.* A coarse-ground finish shall be used to remove excessive roughness such as flash and fins from forged surfaces. This finish shall not be coarser than that resulting from the use of a 30-grit abrasive wheel.

3.4.5 *Natural finish.* A natural finish shall be an even (natural) forged surface, free from fins, scale, or rust. The flash line shall be removed sufficiently to blend smoothly with the adjacent surface or it shall be removed completely. This finish may be attained by grit blasting, tumbling, grinding, machining, or a combination there-

4.4.1 *Hardness (see 3.7).* Suitable grinding or dressing shall be performed over the area or areas to be tested so that any case-hardened surface is removed. The Rockwell hardness tests shall be conducted in accordance with method 243 of Fed. Test Method Std. No. 151.

4.4.1.1 Three or more determinations shall be made of the hardness on the specified portion or portions of the tool. All values determined shall fall within the hardness range specified herein. Hardness determinations of faces shall be made on the faces. For picks, bits, and chisel ends (beveled edges) the measurements shall be made close to the point or edge but not closer than 1/8 inch; for curved claws and ripping claws of type I carpenter's hammers, the measurement shall be made adjacent to the nail pulling wedge or opening at distances greater than 3/8 inch from the ends of the claws. Hammers which have been rim tempered to reduce chipping hazards shall be hardness tested on the face in the untempered area(s).

4.4.3 *Striking test for hammers having overall handle lengths greater than 25 inches.*

4.4.3.1 *Striking test.* The sample tool shall withstand 100 full swinging blows by continuous hand striking, or the mechanical equivalent, on a hardened steel die block showing a hardness reading of Rockwell "40" to "45" C. The sample tool shall have failed this test if the head mushrooms to the extent that cracking develops in the striking faces or edge of the mushroom, or if there are any other signs of failure such as spalling, cracking of the head, or spreading of the eye. The test block shall be 10 inches square or larger; the thickness shall be at least 8 inches. For hand swinging, the die block shall be so supported or mounted that the test face is at knee height (approximately 19 inches above the floor). On double-faced tools, only one selected face shall be tested for compliance with this requirement.

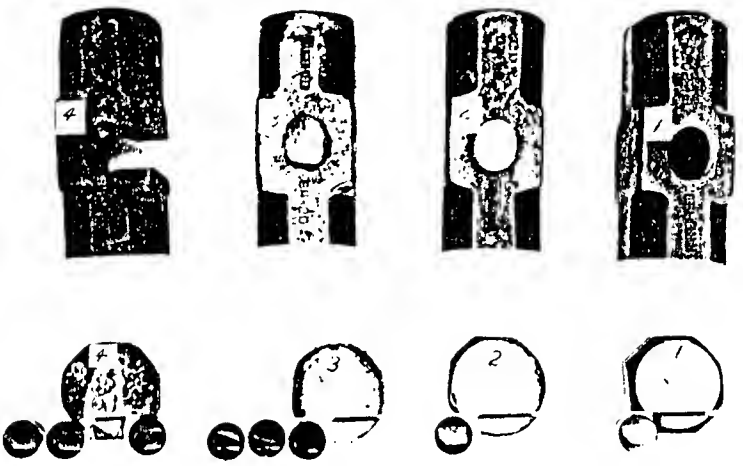


Exhibit A2 Comparison of 4 Type X hammers.

1 new
2 used but not redressed
3 used and redressed (?) times
4 accident hammer

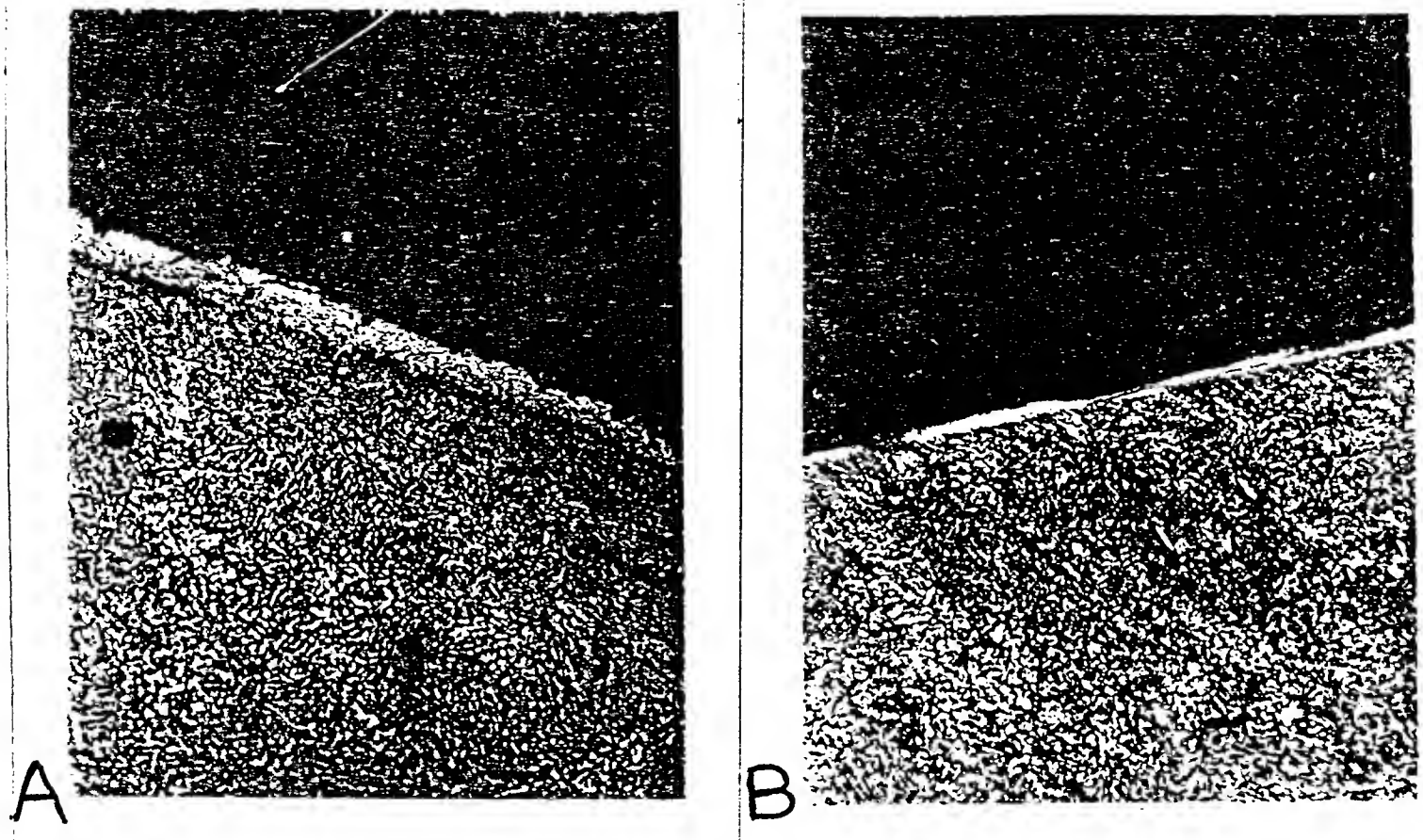
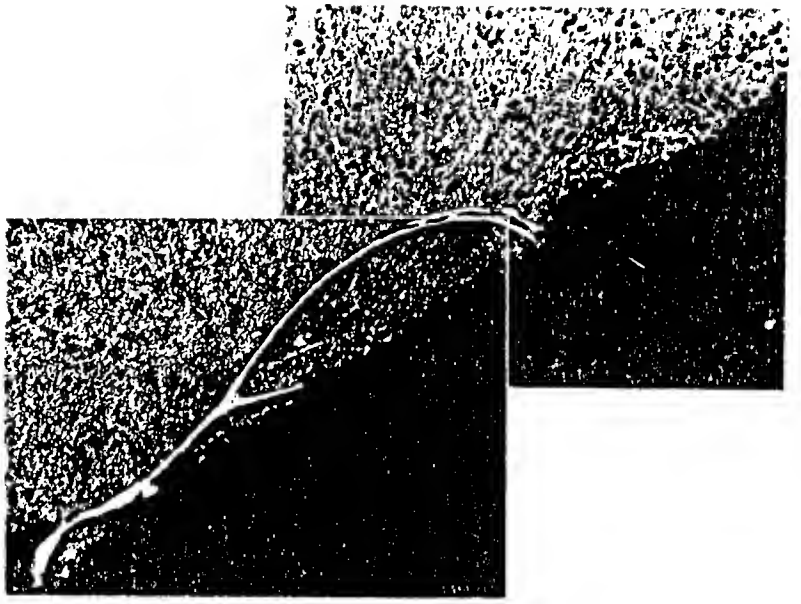


Exhibit A3 White layer on fracture surface 360X

A on edge of face of hammer
B on edge of chip



50X

Exhibit A4 White layer in region of chips

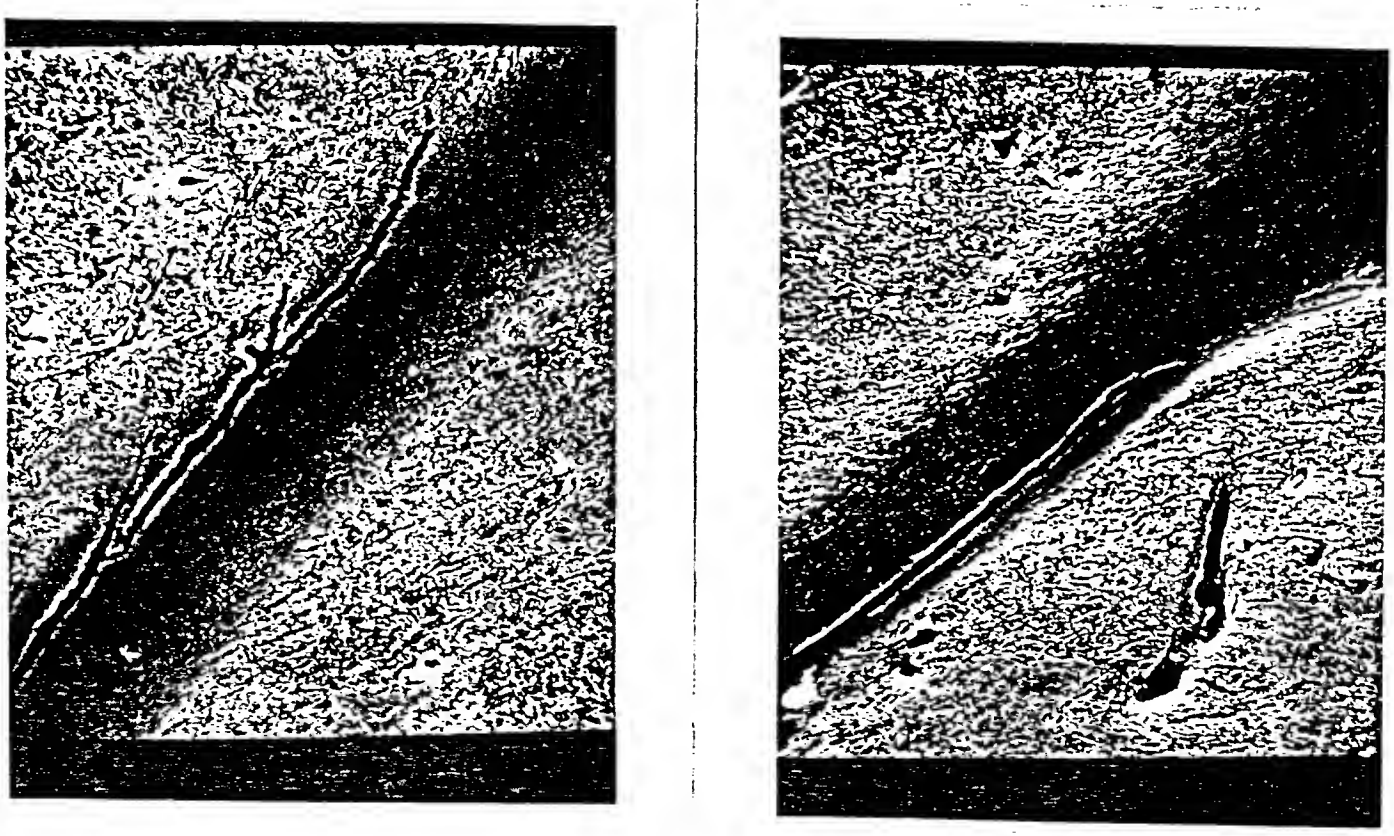


Exhibit A5 Cracks in white layer of Exhibit A4 950X

Exhibit A6 Split white layer in chipped out region of hammer 180X

Exhibit A7 Microhardness impressions in hammer 330X

PART B

Obviously, the white material observed is much harder than the 44-55 Rockwell C hardness permitted by Federal Specification GGG-H-86c. Thus, by legal definition, if no other, the hammer was defective.

What about the measured 42-46C Rockwell hardness? Does GGG-H-86c apply?

The plaintiff's expert, a metallurgist, claimed a defect of retained austenite in the sledge hammer but, under cross examination, admitted he didn't find any in the sledge in question. Two other metallurgists, retained as experts by the two defendants, stated that it was impossible for retained austenite, if present at the time of sale, to have completely disappeared.

What is your opinion on this point?

The two defense experts expressed the opinion that the white material observed in Exhibits A3 through A7 was untempered martensite. The appearance and hardness values are typical and have been rather widely recognized.* Untempered martensite will be under a high compressive stress relative to the original core material. Subsequent impacting with the hammer caused the martensite to crack and produce a flying chip.

What difference does it make if there is retained austenite or untempered martensite, i.e., what are the micro structures, resulting properties, and potential consequences? If the defense experts are correct, what is the source of the untempered martensite? Who is responsible?

RECONSTRUCTION OF EVENTS PRIOR TO ACCIDENT

Repeated use of sledge hammers on hard materials promotes a spreading out or mushrooming of edge metal on the hammer face. To remove this mushroomed layer, it is necessary to use a torch or a grinding wheel. Since grinding wheels are more common in most work places, mushroomed metal is usually ground off.

The maintenance department in the plant where the accident occurred routinely removed the handle and held the hammer to a grinding wheel until the edges were redressed. When the hammer became too hot to hold, it was quenched in a five gallon bucket of water.

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*For example, Vol. 10, 8th Edition, Metals Handbook, ASM, pg 18, 19 (Fig. 11).

It is obvious that as the size of the metal hammer increases, the degree of grinding, usually dry, can be more severe since there is more metal to absorb heat. If a 20 lb. hammer, as a whole, is too hot to hold, it is certain that the temperature at the region being ground is very high.

The source of untempered martensite was the redressing operation. The mushroomed material was highly stressed. The localized grinding temperature was high enough to reach an austenitizing temperature of 1400°-1600°F. Quenching in the water produced the martensite.

While the microstructural changes produced were only in a small portion of the overall piece, this portion is highly critical and produced harmful metal chips.

COMMENTS

The result of the trial was a verdict for both defendants. Some other comments, however, are in order:

Common warnings on sledge hammers are either forged in the head, imprinted in the hickory handle or on an attached label. These warnings generally state that hitting harder surfaces should be avoided and that safety glasses should be worn at all times. For example, one well known source of sledge hammers has "WARNING: WEAR SAFETY GOGGLES" forged in 3/16 inch high letters on the head. This would not, however, have been effective for Mr. D. In no case has a printed warning been found which points out possible material changes due to grinding operations.

In spite of the policy of manufacturers to take in used sledge hammers and warnings about the consequences of continual redressing of striking faces, it is less effort for maintenance men to redress than ship out a hammer. Maintenance men must become aware that continual grinding of hammer faces to save purchasing new hammers can be false economy. Careful consideration should be given to the length of the maintenance schedule and the manner of treatment or else a personal injury may result.

Can you name other tools which might behave in much the same way as this sledge hammer?*

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*"Defect by Definition," Proceedings, Products Liability Prevention Conference 77E, New Jersey Institute of Technology, Newark, New Jersey (22-24 August 1977)